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FAX COVER PAGE

DATE: January 19, 2005 **TIME:** 11:36 pm

TO: Examiner Ronald Laneau (703-872-9306)
Art Unit 3627

FROM: Clyde Christofferson

SUBJECT: 09/551,118

28 **PAGES, INCLUDING COVER PAGE**

BRIEF OF APPELLANTS UNDER 37 C.F.R. §1.192(c)

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of

Feng Cheng et al.

Serial No. 09/551,118 Group Art Unit 3627

Filed April 17, 2000 Examiner R. Laneau

For LARGE INVENTORY-SERVICE OPTIMIZATION IN CONFIGURE-TO-ORDER SYSTEMS

Mail Stop Appeal Brief – Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

CERTIFICATE OF TRANSMISSION UNDER 37 CFR §1.8

Date of Transmission: January 19, 2005

I hereby certify that the foregoing BRIEF OF APPELLANTS UNDER 37 C.F.R. §1.192(c) in connection with the patent application of Feng Cheng et al.for LARGE INVENTORY-SERVICE OPTIMIZATION IN CONFIGURE-TO-ORDER SYSTEMS is being transmitted by facsimile to the USPTO at 703-872-9306, under 37 C.F.R. §1.8 and in accordance with the notice "Patent Customers Advised to FAX Communications to USPTO" dated 11/2/2001 and posted on the USPTO web site http://www.uspto.gov/september11/faxnotice.htm, and as modified by the instruction "Centralized Delivery and Facsimile Transmission Requirements for Patent Application Related Correspondence" issued 10/1/2003.

Clyde R Christofferson

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BRIEF OF APPELLANTS UNDER 37 C.F.R. §1.192(c)

Sir:

A Notice of Appeal from the action of the Primary Examiner in finally rejecting claims 1-15 in this application was timely filed on November 19, 2004. Please charge Deposit account Deposit Account 50-0510 (IBM-Yorktown) in the amount of $500.00 (37 C.F.R. 1.17(c)) to cover the fee for filing this appeal brief.

REAL PARTY IN INTEREST

The real party in interest in this appeal is International Business Machines Corporation, assignee of the entire interest in the above-identified invention.

RELATED APPEALS AND INTERFERENCES

The appellants, their legal representative and the assignee are presently unaware of any appeal or interference which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

STATUS OF THE CLAIMS

Claims 1-15 have been rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,516,301 to Aykin in view of U.S. Patent No. 5,963,919 to Brinkley et al. ("Brinkley"). This rejection is the only rejection of record.

STATUS OF AMENDMENTS

All amendments prior to the request for reconsideration filed September 13, 2004 under 37 C.F.R. §1.116 have been entered. The Advisory action mailed October 19, 2004 indicated that the request for reconsideration filed on September 13, 2004 has been entered. The notice of appeal filed on November 19, 2004 applied to the rejection of all claims.

SUMMARY OF THE INVENTION

The invention is directed to a system and method for optimizing the total cost of inventory components used to build end products in a configure-to-order system. The invention operates by establishing a base stock level for each component and replenishing in accordance with base stock levels so as to reduce the total cost of inventory components, where the cost of each component – and in particular the differences in cost between components – determines the result of the replenishing step.

The invention is responsive to circumstances where the time it takes to assemble an end product is negligible, while the production/replenishment lead time for each component is much more substantial (page 1, lines 14-16). In such circumstances it is most suitable to build the components to stock (BTS) and assemble the end-products to order (ATO), yielding what is called a configure-to-order (CTO) system (page 1, lines 11-13). By keeping inventory at the component level, customer orders can be filled quickly; at the same time, postponing final assembly until order arrival allows greater product variety (page 1, lines 17-20),

thereby enabling each customer to select a personalized set of components for the delivered product (page 2, lines 5-7).

Personal computer (PC) manufacturing is an example of a manufacturing environment suited for the hybrid CTO model (page 1, lines 16-17). In traditional PC manufacturing, an inventory is maintained of both components and end products (page 2, lines 18-20), where a "materials requirements planning" (MRP) type explosion technique is applied to a forecasting or planning horizon to determine the requirement for components, based on the bill-of-materials structure of each end product (page 2, lines 15-18). However, because of a very short product life cycle and declining prices in the PC industry, it is very costly to hold an inventory of end products (page 2, lines 20-23).

The invention makes feasible a migration of traditional PC manufacturing operation to a Web-based CTO operation where customer orders are taken from the Internet (page 3, lines 20-22), and the traditional inventory of end products is eliminated (page 3, lines 22-23), thereby shifting emphasis to the components, which have long lead times and therefore still require inventory (page 3, lines 23-25).

The invention is directed toward an improved inventory strategy for the components of end products, providing a methodology for reducing the total cost of the inventory of the components which are the building blocks for the end products. The methodology is most effective in reducing the total cost of components for end products in circumstances such as personal computer manufacturing, where the cost of certain components of the computer (e.g. processors) are higher than other component (see Table 1 beginning at page 27, line 25). In such circumstances, the invention will realize significant savings by an optimization that is able to reduce the inventory replenishment requirements of the more costly components (see the column for base stock levels R_i and safety factors k_i in Table 7 at page 33).

ISSUES

The sole issue in this Appeal is whether or not claims 1-15 are obvious in view of the teachings or suggestions of Aykin in view of Brinkley within the level of ordinary skill in the art discernable therefrom. Included within this issue are questions of a) whether or not the references and the state of the art discernable therefrom lead to an expectation of success in achieving the function of the invention in accordance with the subject matter of the claims, b) operability of the references for the intended purposes after modification as suggested by the Examiner, c) the propriety of the modification of references and motivation therefor, d) whether hindsight has been employed by the Examiner and c) whether or not a *prima facie* demonstration of obviousness of any claim has been made by the Examiner.

GROUPING OF CLAIMS

The rejected claims do <u>not</u> stand or fall together. The reasons why appellants consider the rejected claims to be separately patentable are set out in the following section, entitled "ARGUMENT".

ARGUMENT

The Prior Art

U.S. Patent No. 6,516,301 to Aykin

Aykin describes an order based materials management method using forecasts of customer orders to determine stocking levels for the components that must be assembled to fill an order for end products. Aykin focuses on the percentage of customer orders filled within the time interval promised (col. 2, lines 4-10), a metric which depends upon the percentage of such orders which do not have to wait for components at the time the order arrives (col. 2, lines 15-16). This second percentage

is called the "order fill rate"(col. 2, line 17; col. 3, lines 1-3). The problem addressed by Aykin was that existing material management systems determined component inventory requirements separately for each component (col. 2, lines 22-23), without taking into account the composition of orders (col. 2, lines 24-25), in particular orders for highly customized products (col. 2, lines 36-43). The solution of Aykin was to forecast these customer orders, rather than forecast demand for individual components (col. 2, lines 44-47). Aykin then determines the buffer level (i.e. inventory stock level) of the various components necessary to reach a desired fill rate (col. 3, lines 1-4; lines 11-18; lines 32-40).

U.S. Patent No. 5,963,919 to Brinkley et al. ("Brinkley")

Brinkley discloses a system and method for combining multiple management strategies in a single inventory management system. The system analyzes the inventory portfolio on an item-by-item basis to assign the most suitable management strategy for that item (Abstract). Brinkley provides a method for evaluating and classifying individual inventory items and recommending for each item which one of six generic inventory strategies (col. 4, lines 21-34) would be optimal (col. 2, lines 48-51). For each of the six management strategies Brinkley addresses four basic questions for developing an inventory management strategy (col. 4, lines 31-34). These questions are 1) who is responsible for initializing replenishment of a particular item (col. 4, lines 34-48); 2) what are the trigger levels and policies (such as Kanban) for replenishment (col. 4, lines 49-61); 3) what are the mechanics of monitoring the replenishment process (col. 4, line 62, to col. 5, line 8); and 4) what quantity is to be ordered once the replenishment decision is made (col. 5, lines 9-15).

Brinkley describes the six inventory strategies in terms of the characteristics of inventory items: 1) Make-to-Order is appropriate for rare demands; no stock is held in the warehouse and orders are manufactured as needed (col. 5, lines 21-23); 2) Replenish-to-Order (Kanban) is optimal with rare demand items, where customer order interval is sometimes shorter than the supply lead time and cost is high relative

to volume (col. 5, line 58); a small stock is maintained in the warehouse, which is replenished as it is depleted (col. 5, lines 43-47); 3) Warehouse Replenishment is appropriate for items replenished based on make-to-stock reorder points; there is a cost optimized level of stock held in the warehouse (col. 6, lines 9-12), for example, quantity discounts are obtained upon purchase (col. 6, line 28); 4) Fixed-Rate-Supply works well with high volume, stable demand, commodity items; continuous production, allocated as product comes off the manufacturing line (col. 6, lines 38-40); 5) Multi-Input Expert Planning is an optimal strategy where cost, trend, or variability of item demand justifies expert planning (col. 6, lines 62-67); and 6) Forecast Optimal is the appropriate strategy for items having a demand history with patterns supporting statistical forecasting (col. 7, lines 26-28).

Both the Warehouse Replenishment and Multi-Input Expert Planning strategies use the Economic Order Quantity (EOQ) concept to determine the quantity of the item reordered at replenishment time. According to the EOQ concept, the reorder amount is a function of the number of items ordered over the time period multiplied by the ratio of setup costs per order to the costs attributed to holding an item in inventory (col. 13, lines 50-57. The holding cost figure is a cost percentage allocated over unit costs (col. 13, line 57).

The Claimed Invention

The claimed invention, as recited in independent claim 1, is a method of managing manufacturing logistics of end products. An inventory is maintained of components, which are the building blocks of end products and are built to stock. The end products are configured to order. The method establishes a base stock level for each of the components, and replenishes the components in accordance with the base stock level so as to reduce the total cost of inventory of the components, where the cost of at least one components differs from the cost of at least one other component. Claim 2 particularizes the invention to personal computer manufacturing, and claim 3 provides for derivation of base stock levels using a

greedy algorithm to reach a budget constraint for an inventory budget. Claims 5-7 are system claims corresponding to method claims 1-3.

Another aspect of the invention is recited in claim 4, which is a computer implemented process of managing manufacturing logistics of configure-to-order end products. The details of the process are set forth with mathematical precision, beginning with a description of the relationship between end products and their respective components, and defining a probability of stockout of an end product and an inventory budget for all end products. The process minimizes the total cost of inventory of the components, wherein the cost of at least one component differs from the cost of at least one other component.

Another aspect of the invention is recited in claim 8, which is a method that translates end-product demand (forecast in an assemble-to-order environment) into a forecast for components. End products are defined in terms of components, and the components are replenished following a base stock policy that minimizes a total cost of inventory of the components, wherein the cost of at least one component differs from the cost of at least one other component, and wherein the difference determines the result of the replenishing step. Claim 9 extends the ATO environment to a CTO environment for stationary demand, taking into account batch sizes. Claim 10 extends claim 9 to non-stationary demand. Claim 11 adds to claim 9 a definition of reorder points, which are translated into days of supply. Claim 12 modifies claim 11 by providing that the stationary demand is invariant in distribution over time.

Another aspect of the invention is recited in claim 13, which is a method that relates service requirements to base-stock levels of components in an assemble-to-order environment. Orders are defined as requiring exactly one unit of each component, with a required service level being off-shelf availability for the required components, with an out of stock event also being defined. Base stock levels are established for each component that minimize a total cost of inventory of the components, wherein the cost of at least one component differs from the cost of at least one other component, and wherein the difference determines the result of the

step of establishing base stock levels. Claim 14 extends the ATO environment to a CTO environment, taking into account batch sizes.

Another aspect of the invention is recited in claim 15, which is a method that translates service requirements in terms of lead times into requirements for off-shelf availability of components. Off-shelf availability requirements are related to standard customer service requirements expressed in terms of lead times, and the components are replenished following a base stock policy that minimizes a total cost of inventory of the components, wherein the cost of at least one component differs from the cost of at least one other component, and wherein the difference determines the result of the replenishing step.

The Examiner's Application of the Prior Art

The Examiner has rejected claims 1-15 under 35 U.S.C. §103(a) as being unpatentable over Aykin in view of Brinkley. The Examiner acknowledges that Aykin does not teach that components have different costs, and that Aykin does not teach that the difference is costs determines the result of the replenishing step. The Examiner cites Brinkly as teaching an inventory management strategy wherein the different costs of components determines the replenishment of that component.

Prosecution Background

The Examiner's consideration in allowing a telephone interview in this case on November 11, 2004, is acknowledged with appreciation. Inventor Dr. Markus Ettl participated in the interview, along with the undersigned counsel for the applicant. An Article 132 Declaration by Dr. Ettl was presented to the Examiner for the interview and served to guide the discussion. At the outset of the interview counsel briefly reviewed the history of this prosecution, noting the prior interview with former Examiner Brian Jaketic on April 1, 2004. Dr. Ettl then reviewed the Aykin

reference which had been addressed in the earlier interview, noting that Aykin – like the present invention – is applicable to large scale inventory management. See paragraphs 5 through 7 of the Declaration of Dr. Ettl attached to the applicant's interview summary. The Examiner asked Dr. Ettl whether the $100,000 difference in inventory costs between Aykin and the present invention, as shown in the chart attached to the Article 132 Declaration (and previously as Attachment A to the prior response), was significant, Dr. Ettl replied that this difference of about 10% was significant for the computer business.

Dr. Ettl then reviewed the Brinkley reference, noting that – unlike Aykin – Brinkley did not address the assembly-type inventory management problems addressed by the present invention, and could not be applied thereto. Brinkley provided a method for evaluating and classifying individual inventory items and recommending for each item which one of six generic inventory strategies would be optimal. But the six inventory strategies are well known, and there is nothing in them or in Brinkley to suggest application to the inventory management problem addressed in Aykin and the present invention.

It had been demonstrated to the satisfaction of the prior examiner that Aykin's method did not consider cost differences between components in a bill-of-materials, and that Aykin's cost optimization method only produced the same result as the present invention when all components have the same cost (see ¶¶5-7 of the Article 132 Declaration). Over the course of two rounds of rejections based on Aykin, including an RCE, the following limitation was added to the claims:

> <u>wherein said cost of at least one component differs from said cost of at least one other component, and wherein said difference determines the result of said replenishing step</u>.

At this point in the prosecution, on April 1, 2004, a first interview was conducted and the examiner was persuaded that the Aykin reference had been overcome. In

response, and prompting a further final rejection, the Brinkley reference was found. It was acknowledged that Aykin does not teach that the difference in cost of components determines the result of the replenishing step. It was asserted that Brinkley teaches an inventory management strategy wherein the different costs of components determines the replenishment of that component.

The Differences Between the Prior Art
and the Claimed Invention

This assertion was traversed in the applicant's after-final response submitted on September 13, 2004. The claims were not further amended. The Brinkley reference, internally and on its own terms, considers replenishment of individual inventory items, with a separate recommendation of an optimal inventory strategy for each item (see, esp. col. 8, lines 53-54).

While two of the six standard inventory strategies consider cost, this is in the form of an economic order quantity (EOQ) pertaining to a particular item (see col. 13 of Brinkley). As the above discussion of the Brinkley reference makes clear, the appearance of "unit cost" in the EOQ formula is dubious support for the Examiner's contention, even if that contention is narrowed – as it must be narrowed – to apply to individual items (which may or may not be components). A close examination of the EOQ formula disclosed in Brinkley indicates that the primary factor is the demand during a time period. The EOQ formula is not a cost, but a number of units per time period, as a conventional dimensional analysis of the formula shows. This number of units is adjusted by, among other factors, a ratio of setup costs (for an order) to holding costs (i.e. the costs attributed to holding an item in the inventory). The use of this ratio is easily understood. If setup costs are higher relative to holding costs, then it makes sense to increase the number of units in the replenishment so that replenishments will not have to be repeated as often. Similarly, if holding costs are

higher, then it makes sense to decrease the number of units in the replenishment so that holding costs will be reduced.

How are "holding costs" determined? Apparently (col. 13, line 25), the costs attributable to holding items in inventory (e.g. the cost of storage in a warehouse) are aggregated and divided by some figure to arrive at a "holding cost percentage". As is well known in the accounting field, such costs may be treated as overhead or allocated directly to sales units. As is also well known in the accounting field, there are a variety of sound bases for allocating such costs. In the case of warehouse costs, it would be reasonable to allocate on the basis of square feet of warehouse space taken up by the inventory. Instead, however, in the EOQ described by Brinkley, the allocation has been made on the basis of the cost of the items in the inventory. As will be appreciated by one skilled in the accounting arts, this is a reasonable basis for allocation, all the more so because it is easier to determine from available data.

However, the point is that using unit cost as a basis for allocating "holding costs" in an EOQ formula is a far cry from considering actual item costs. In fact, as the above discussion makes clear, Brinkley does <u>not</u> teach "an inventory management strategy wherein the different costs of components determines the replenishment of that component" as the Examiner contends. The Examiner's contention is an illusion, an illusion spawned from mere mention of "unit cost" without analysis of its context. As the earlier comparison between Aykin and the present invention demonstrated, although Aykin does not consider component cost at all, the Aykin method will yield the same result <u>if it is assumed that all components of an end product have the same cost</u>. This is highly unlikely to occur. As the comparison table discussed at the April 1, 2004 interview and of record in the case demonstrates, the present invention produces a significant savings over the Aykin method where there are cost differences between components. It is in this sense that these cost differences "determine" the results of the replenishment step. The limited use of the cost of an item in Brinkley falls far short of "determining" the replenishment even of that item,

and says nothing at all about the role in replenishment of component to component (within an end product) cost differences.

Further, it should be noted that the EOQ formula is applied to answer the question "how much" of the item should be ordered when replenishing stock under the third and fifth standard methods of inventory management identified by Brinkley (col. 6, line 18; col 7, line 8). There is no connection in Brinkley between items. While it may be assumed that different items have different costs, this assumption is not provided by Brinkley nor is it relevant to Brinkley's teaching. Similarly, building upon that unsupported and irrelevant assumption, it may also be assumed that different items will have different costs. Again, there is no basis in Brinkley or any relevance in Brinkley for making this assumption. Building on top of this further unsupported and irrelevant assumption, one may also suppose that different items with different costs may be assigned to the same one of the six standard inventory management strategies identified by Brinkley, and in particular may be assigned to one of the strategies (i.e. Warehouse Replenishment or Multi-Input Expert Planning) that actually uses item cost.

However, Brinkley neither draws a distinction between nor a connection between "end products" and "components." Brinkley only discusses inventory "items." Since Brinkley's method utterly fails to suggest any relevant connection between items – much less any relevant connection between the costs of different items (which, in Brinkley, may or may not be components for an end-product), it is imaginative but not patentably significant to further build upon this series of unsupported and irrelevant assumptions by arguing that independent assignment of a plurality of items to one inventory management strategy, each having separately considered costs and separately calculated replenishment, teaches "different costs of components". For this argument to make sense it would be necessary to make the further assumption – again, an assumption not supported by Brinkley or relevant to Brinkley – that the items having different costs a) were components and b) were components of the same end product.

Nor is this relevant to what is missing from Aykin with respect to the present invention. What is missing from Aykin – and NOT supplied by Brinkley – is the relevance, for determining the replenishment of components of an end product, of cost differences between these components. It should be emphasized that Brinkley says nothing and suggests nothing about the connection between an end product and its respective components. This point is also made by Dr. Ettl's statement that Brinkley "does not capture interdependencies introduced through bills-of-material" (Declaration, ¶10). These interdependencies of components are stated in the claims by reference to the term "end products" for which components are "building blocks." Brinkley lacks this critical interdependence of components, and therefore "can not be combined with or extended to an assembly-type model such as Aykin's or ours" (Declaration, ¶10).

Therefore Brinkley fails as a reference in two particulars. First, it does not teach the relevance of component cost differences to replenishment of components, where these components are "building blocks" for end products. Instead, Brinkley merely provides the obvious observation that where cost of an item is a factor in determining replenishment of that item (but where the cost of other items has no relevance), item cost is a factor in determining replenishment. Repeating that observation for a plurality of unrelated items (which may or may not be components of a common end product) does not teach what is missing from Aykin. Second, Brinkley fails as a reference because it lacks any consideration of bills-of-material, end products comprised of components, or any other connection to the assembly-type model described in both Aykin and the present invention. Absent that connection, no one skilled in the art would apply Brinkley (assuming Brinkley contained a relevant teaching) to Aykin.

CONCLUSION

In summary, it is respectfully submitted that the claimed subject matter cannot properly be considered to be obvious based on the teachings of Aykin and Brinkley or the level of ordinary skill in the art determinable therefrom. Central to the present invention (and also to Aykin) is the relationship between end products and their respective components. That relationship is completely absent in Brinkley. It is doubtful whether Brinkley teaches any connection between component cost differences and a replenishment that applies not to a plurality of components but to components in relationship to end products. But even if Brinkley had a teaching relevant to what is missing from Aykin, it would be necessary to have a component/end-product relationship in order for one skilled in the art to apply Brinkley to Aykin. All the independent claims rely on this relationship, and contain the limitation of component cost differences. Therefore, the foregoing argument applies to all claims 1-15 and to the Examiner's contentions regarding a combination of Aykin and Brinkley as making these claims obvious.

Therefore, it is respectfully submitted, as demonstrated above, that the prior art references relied upon by the Examiner does not contain the teachings or suggestions the Examiner attributes to them and do not provide evidence of a level of ordinary skill in the art which would support the conclusion of obviousness that the examiner has reached. Moreover, to answer the claimed subject matter, the combination of references applied would require further modification which would preclude their intended function and therefore the combination is improper and/or insufficient to answer the claims and the further modification assumed by the Examiner's statement of the rejection is without motivation. Finally, the Examiner appears to have confused or glossed the very different circumstances of the references relied upon from each other which precludes a *prima facie* demonstration of obviousness of any claim in the application.

In view of the foregoing, it is respectfully submitted that the final rejection of claims 1-15 based on Aykin and Brinkley is in error. Accordingly, reversal of the final rejection is respectfully requested.

Respectfully submitted,

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APPENDIX

THE CLAIMS ON APPEAL

The claims on appeal are as follows

1. A method of managing manufacturing logistics of end products comprising the steps of:

maintaining an inventory of components, which components, termed "building blocks", are built to stock, each said component having a cost;

configuring-to-order end products using said components;

establishing a base-stock level for each of said components; and

replenishing said components from suppliers in accordance with said base-stock levels so as to reduce a total cost of inventory of said components,

wherein said cost of at least one component differs from said cost of at least one other component, and wherein said difference determines the result of said replenishing step.

2. The method of managing manufacturing logistics of end products recited in claim 1, wherein the end products are personal computers (PCs) and the components are stock computer components.

3. The method of managing manufacturing logistics of end products recited in claim 1, wherein the base-stock levels are derived from a greedy algorithm which iteratively reduces inventory budget until a budget constraint is satisfied.

4. A computer implemented process of managing manufacturing logistics of configure-to-order end products comprising the steps of:

a) initializing a process of managing manufacturing logistics of configure-to-order end products by setting $x_i := 0$ for each $i \in S$, setting $r_{mi} := P(X_{mi} > 0)$, setting $\beta_m := 0$ for each $m \in M$, and setting $\beta := 0$, where S is a set of components indexed by i, M is a set of end products indexed by m, x_i is a probability of no-stockout of a component of index i, r_{mi} is a probability that a positive number of units of component i is used in the assembly of an end product indexed by m, β_m is a probability of stockout of an end product of index m, and β is an upper limit on the stockout probability over all end products;

b) setting a set of active components to $A := \{\}$;

c) considering each $i \in S$, followed by considering each end product m that uses component i in its bill-of-material;

d) setting $\beta_m := \beta_m + r_{mi}\Delta$, for all m such that $i \in S_m$ where Δ is a unit step size;

e) computing a difference $\delta_i := \max_m\{\beta_m\} - \beta$;

f) determining if $\delta_i \leq 0$, and if so, then adding component index i to the set of active components, $A := A + \{i\}$;

g) determining if the set of active components is non-empty, and if so, then setting B := A, otherwise setting B := S where B is a set of component indexes;

h) finding $i^* := \arg\max_{i \in B}\{-c_i\sigma_i/r_{mi}\, g'(x_i + \Delta/2)\}$, where $-g'(\bullet)$ follows the equation $-g'(x) = -\Phi(\bar{\Phi}^{-1}(x))\cdot\frac{-1}{\phi(\bar{\Phi}^{-1}(x))} = \frac{1-x}{\phi(\bar{\Phi}^{-1}(x))}$, where $\Phi(.)$ is a probability distribution function of the standard normal variate, and $\phi(.)$ is a probability density function of the standard normal variate;

i) setting $x_i^* := x_i^* + \Delta$ to update the probability of no-stockout of component i^*;

j) computing $\beta := \max_{m \in M} \beta_m$, and checking whether inequality $\sum_{i \in S} c_i \sigma_i g(x_i) \le B$, where B is the budget limit on the expected overall inventory cost, is satisfied and if so, stop and replenish components identified by said set B from suppliers following a base-stock policy that minimizes a total cost of inventory of said components i,

wherein said cost c_i of at least one component differs from said cost c_i of at least one other component ;

k) otherwise, updating β_m and for each $m \in M_{i*}$, set $\beta_m := \beta_m + r_{mi} \Delta$, and going to step b).

5. A system for managing manufacturing logistics of end products comprising:

means for maintaining an inventory of components, which components, termed "building blocks", are built to stock, each said component having a cost;

means for configuring-to-order end products using said components;

means for establishing a base-stock level for each of said components; and

means for replenishing said components from suppliers in accordance with said base-stock levels so as to minimize a total cost of inventory of said components,

wherein said cost of at least one component differs from said cost of at least one other component, and wherein said difference determines the result produced by said replenishing means.

6. The system for managing manufacturing logistics of end products recited in claim 5, wherein the end products are personal computers (PCs) and the components are stock computer components.

7. The system for managing manufacturing logistics of end products recited in claim 5, wherein the base-stock levels are derived from a greedy algorithm which is iteratively computed by a processing unit to reduce inventory budget until a budget constraint is satisfied.

8. A method that translates end-product demand forecast in an assemble-to-order (ATO) environment into a forecast for components, taking into account outbound leadtime comprising the steps of:

defining in an assemble-to-order (ATO) environment an end product demand $D_m(t)$ of type m in period t, each unit of type m demand requiring a subset of components, denoted $S_m \subseteq S$, as

$$D_i(t) = \sum_{m \in M_i} D_m(t + L_m^{\text{out}}); \text{ [and]}$$

deriving mean and variance for component demand $D_i(t)$ as

$$\mathrm{E}[D_i(t)] = \sum_{m \in M_i} \sum_{\ell} \mathrm{E}[D_m(t+\ell)]\mathrm{P}[L_m^{\text{out}} = \ell], \text{ and}$$

$$\mathrm{Var}[D_i(t)] = \sum_{m \in M_i} \sum_{\ell} \mathrm{E}[D_m^2(t+\ell)]\mathrm{P}[L_m^{\text{out}} = \ell] - \sum_{m \in M_i} \left(\sum_{\ell} \mathrm{E}[D_m(t+\ell)]\mathrm{P}[L_m^{\text{out}} = \ell] \right)^2, \text{ respectively; and}$$

replenishing said components from suppliers following a base stock policy that minimizes a total cost of inventory of said components, each said component having a cost,

wherein said cost of at least one component differs from said cost of at least one other component, and wherein said difference determines the result of said replenishing step.

9. The method recited in claim 8, wherein the ATO environment is extended to a configure-to-order (CTO) environment for stationary demand, taking into account batch sizes comprising the steps of:

translating end-product demand into demand for each component i (per period) as

$$D_i = \sum_{m \in M_i} \sum_{k=1}^{D_m} X_{mi}(k).$$

where $X_{mi}(k)$, for $k = 1, 2, \ldots$, are independent, identically distributed (i.i.d.) copies of X_{mi};

deriving marginal distributions, and then the mean and the variance of X_{mi} as

$$\mathrm{E}[D_i] = \sum_{m \in M_i} \mathrm{E}[X_{mi}]\mathrm{E}[D_m], \text{ and}$$

$$\begin{aligned}\mathrm{Var}[D_i] &= \sum_{m \in M_i} \left(\mathrm{E}[D_m]\mathrm{Var}[X_{mi}] + \mathrm{Var}[D_m]\mathrm{E}^2[X_{mi}]\right) \\ &= \sum_{m \in M_i} \left(\mathrm{E}^2[X_{mi}]\mathrm{E}[D_m^2] + \mathrm{Var}[X_{mi}]\mathrm{E}[D_m] - \mathrm{E}^2[X_{mi}]\mathrm{E}^2[D_m]\right), \text{ respectively.}\end{aligned}$$

10. The method recited in claim 9, extended to non-stationary demand, wherein the mean and the variance of X_{mi} are generalized as

$$\mathrm{E}[D_i(t)] = \sum_{m\in M_i} \mathrm{E}[X_{mi}] \sum_{\ell} \mathrm{E}[D_m(t+\ell)] \mathrm{P}[L_m^{\mathrm{out}}=\ell], \text{ and}$$

$$\begin{aligned}\mathrm{Var}[D_i(t)] = & \sum_{m\in M_i} \mathrm{E}^2(X_{mi}) \sum_{\ell} \mathrm{E}[D_m^2(t+\ell)] \mathrm{P}[L_m^{\mathrm{out}}=\ell] \\ & + \sum_{m\in M_i} \mathrm{Var}(X_{mi}) \sum_{\ell} \mathrm{E}[D_m(t+\ell)] \mathrm{P}[L_m^{\mathrm{out}}=\ell] \\ & - \sum_{m\in M_i} \mathrm{E}^2(X_{mi}) \left(\sum_{\ell} \mathrm{E}[D_m(t+\ell)] \mathrm{P}[L_m^{\mathrm{out}}=\ell] \right)^2, \text{ respectively.}\end{aligned}$$

11. The method recited in claim 9, further comprising the steps of:

defining $R_i(t)$ as a reorder point (or, base-stock level) in period t as

$$R_i(t) := \mu_i(t) + k_i(t)\sigma_i(t),$$

where $k_i(t)$ is a desired safety factor, while $\mu_i(t)$ and $\sigma_i(t)$ can be derived (via queuing analysis) as

$$\mu_i(t) = \sum_{s=t}^{t+\ell_i^{\mathrm{in}}-1} \mathrm{E}[D_i(s)], \text{ and}$$

$$\sigma_i^2(t) = \sum_{s=t}^{t+\ell_i^{\mathrm{in}}-1} \mathrm{Var}[D_i(s)], \text{ respectively,}$$

where $\ell_i^{\text{in}} := \mathrm{E}[L_i^{\text{in}}]$ is expected in-bound leadtime; and

translating $R_i(t)$ into "days of supply" (DOS), where the $\mu_i(t)$ part of $R_i(t)$ translates into periods of demand and the $k_i(t)\sigma_i(t)$ part of $R_i(t)$ is turned into

$$\frac{k_i(t)\sigma_i(t)}{\dfrac{\mu_i(t)}{\ell_i^{\text{in}}}}$$

periods of demand so that $R_i(t)$ is expressed in terms of periods of DOS as

$$\mathrm{DOS}_i(t) = \ell_i^{\text{in}}\left[1 + k_i(t)\frac{\sigma_i(t)}{\mu_i(t)}\right].$$

12. The method recited in claim 11, wherein demand is stationary in which for each demand class m, $D_m(t)$ is invariant in distribution over time, so that the mean and the variance of demand per period for each component i reduce to

$$\mu_i = \ell_i^{\text{in}}\mathrm{E}[D_i], \text{ and } \sigma_i^2 = \ell_i^{\text{in}}\mathrm{Var}[D_i], \text{ respectively, and}$$

$$R_i = \ell_i^{\text{in}}E[D_i] + k_i\sqrt{\ell_i^{\text{in}}}\ \mathrm{sd}[D_i], \text{ and hence,}$$

$$\mathrm{DOS}_i = \frac{R_i}{\mathrm{E}[D_i]} = \ell_i^{\mathrm{in}} + k_i\theta_i\sqrt{\ell_i^{\mathrm{in}}} = \ell_i^{\mathrm{in}}\left[1 + k_i\frac{\theta_i}{\sqrt{\ell_i^{\mathrm{in}}}}\right],$$

where $\theta_i := \mathrm{sd}[D_i]/\mathrm{E}[D_i]$ is the coefficient of variation of the demand *per period* for component i, and hence $\theta_i/\sqrt{\ell_i^{\mathrm{in}}}$ is the coefficient of variation of the demand over the leadtime ℓ_i^{in}.

13. A method that relates service requirements to base-stock levels of components in an assemble-to-order (ATO) environment comprising the steps of:

defining in an assemble-to-order (ATO) environment each order of type m as requiring exactly one unit of component $i \in S_m$, α as a required service level, referred to as off-shelf availability of all the components required to configure a unit of type m product, for any m, and E_i as an event that component i is out of stock;

determining a probability P for each end product $m \in M$,

$$\mathrm{P}[\cup_{i\in S_m} E_i] \le 1-\alpha, \text{ and}$$

$$\mathrm{P}[\cup_{i\in S_m} E_i] = \sum_i \mathrm{P}(E_i) - \sum_{i<j}\mathrm{P}(E_i \cap E_j) + \sum_{i<j<k}\mathrm{P}(E_i \cap E_j \cap E_k) - \cdots, \text{ and}$$

$$\mathrm{P}[\cup_{i\in S_m}] \approx \sum_{i\in S_m}\mathrm{P}(E_i) = \sum_{i\in S_m}\bar{\Phi}(k_i) \le 1-\alpha; \text{ and}$$

establishing base stock levels for each component i that minimize a total cost of inventory of said components, each said component having a cost,

wherein said cost of at least one component differs from said cost of at least one other component, and wherein said difference determines the result of said step of establishing base stock levels.

14. The method recited in 13, wherein the method is extended to a configure-to-order (CTO) environment taking into account batch sizes, further comprising the steps of:

defining $A \subseteq S_m$ as a certain configuration, which occurs in a demand stream with probability $P(A)$;

weighting a no-stockout probability, $\prod_{i \in A} \Phi(k_i)$, by $P(A)$;

changing the service requirement to

$$\begin{aligned} \alpha &\le \sum_{A \subseteq S_m} P(A) \prod_{i \in A} \Phi(k_i) \\ &\approx \sum_{A \subseteq S_m} P(A) \, [1 - \sum_{i \in A} \bar{\Phi}(k_i)] \\ &= 1 - \sum_{A \subseteq S_m} P(A) \sum_{i \in A} \bar{\Phi}(k_i) \\ &= 1 - \sum_{i \in S_m} \left(\sum_{i \in A} P(A) \right) \bar{\Phi}(k_i); \text{ and} \end{aligned}$$

extending the CTO environment the service requirement to

$$\sum_{i \in S_m} r_{mi} \bar{\Phi}(k_i) \le 1 - \alpha$$

where r_{mi} is the probability that a positive number of units of component i is used in the assembly of an end product indexed by m.

15. A method that translates service requirements in terms of leadtimes into requirements for off-shelf availability of components comprising the steps of:

relating an off-shelf availability requirement to standard customer service requirements expressed in terms of leadtimes, W_m, where a required service level of type m demand is

$$P[W_m \le w_m] \ge \alpha, \quad m \in M,$$

where w_m's are given data and P is probability;

when there is no stockout at any store $i \in S_m$, denoting the associated probability as $\pi_{0m}(t)$, a delay being L_i^{out}, the out-bound leadtime;

when there is a stockout at one or several stores in the subset $s \subseteq S_m$, denoting the associated probability as $\pi s_m(t)$, so that the delay becomes $L_i^{out} + \tau_s$, where τ_s is the additional delay before the missing components in s become available;

determining $P[W_m \le w_m] = \pi_{0m}(t) P[L_m^{out} \le w_m] + \sum_{s \in S_m} \pi_{sm}(t) P[L_m^{out} + \tau_s \le w_m]$;

assuming that

$$L_m^{out} \le w_m \quad \text{and} \quad L_m^{out} + \tau_s > w_m$$

both hold *almost surely*, so that when the (nominal) outbound leadtime is nearly deterministic and shorter than what customers require, whereas the replenish leadtime for any component is substantially longer; and

replenishing said components from suppliers following a base stock policy that minimizes a total cost of inventory of said components, each said component having a cost,

wherein said cost of at least one component differs from said cost of at least one other component, and wherein said difference determines the result of said replenishing step.